Mitigation of CO_2 Geological Use and Storage

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Canada

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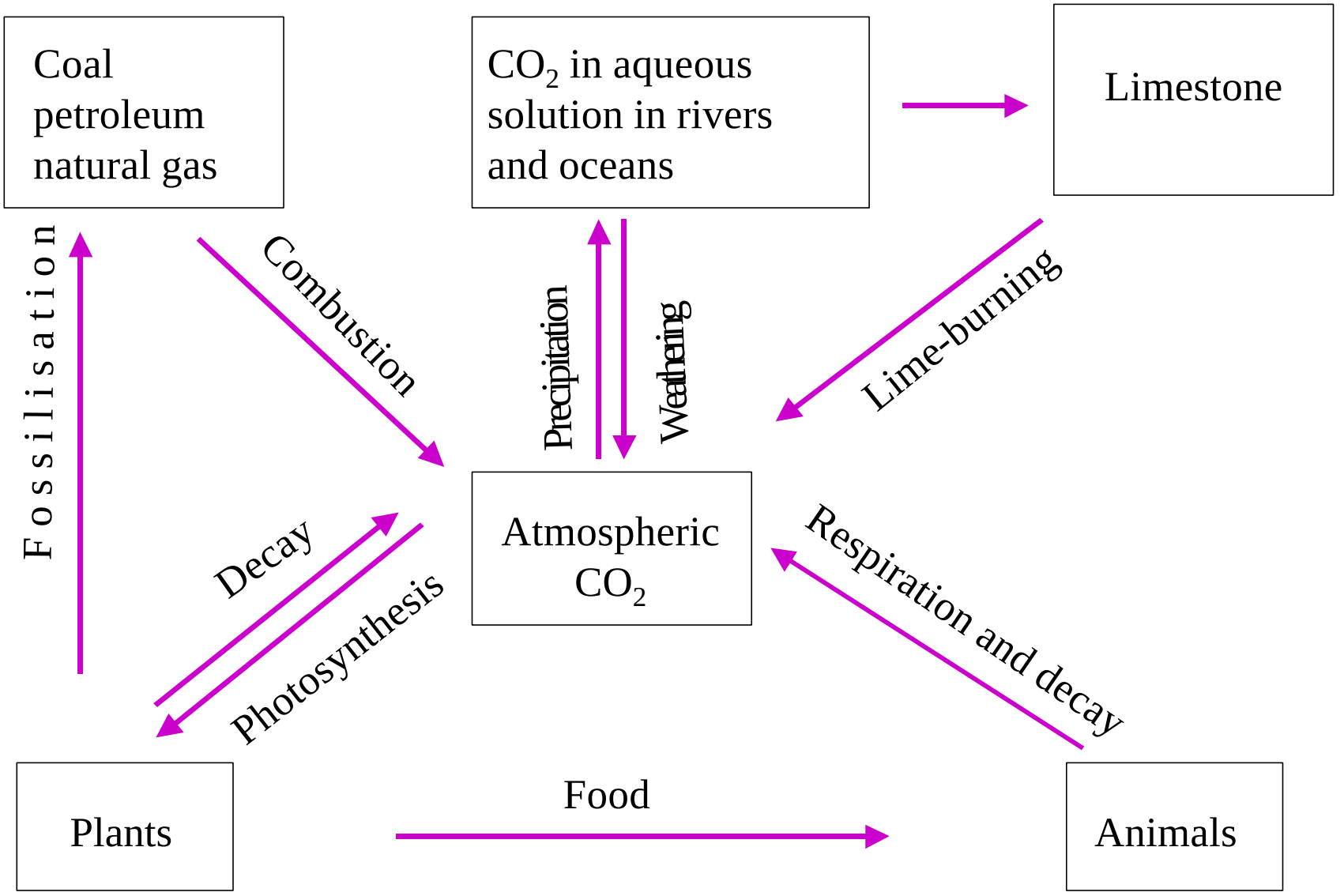
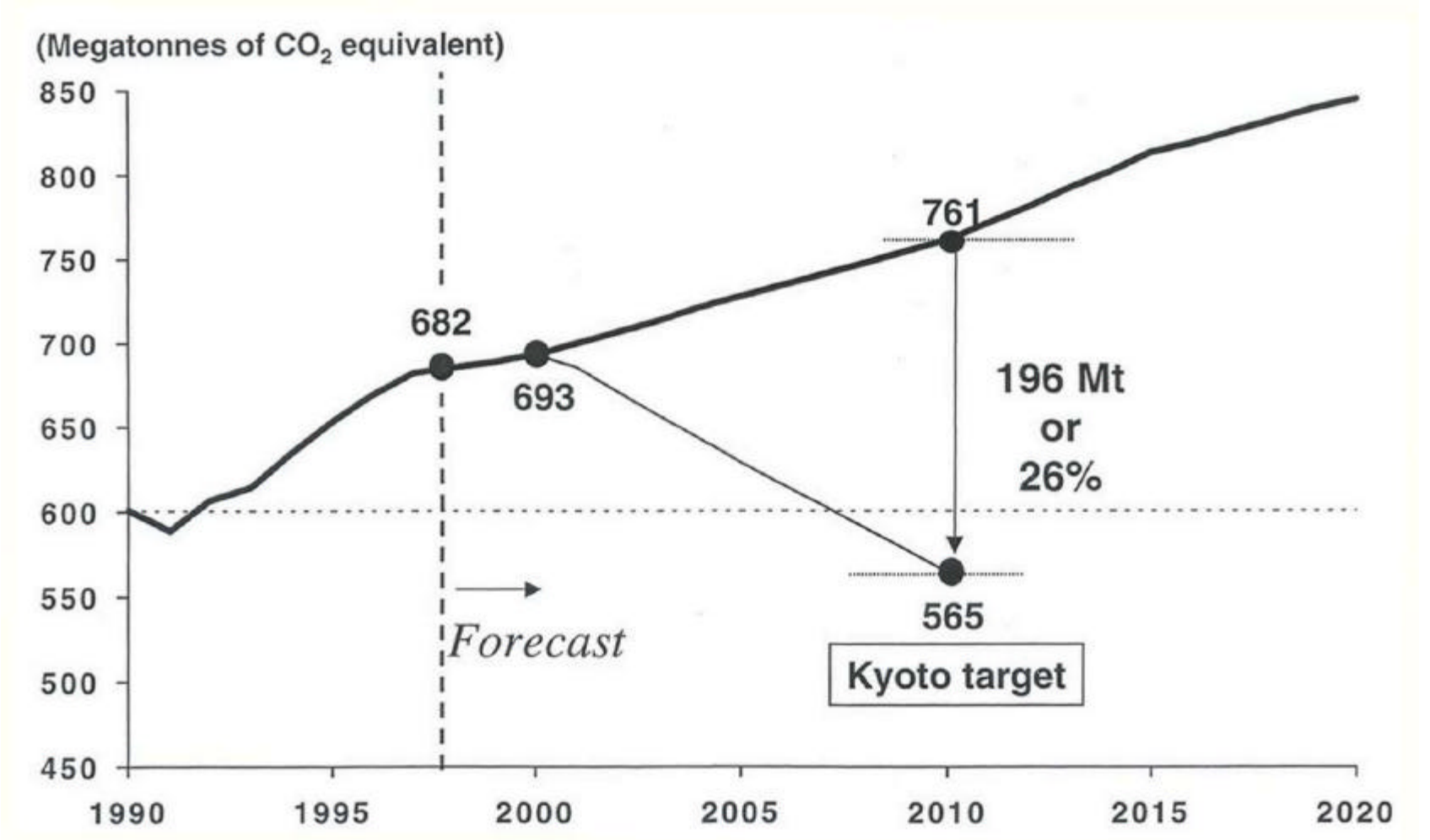
The Climate Change Debate

- Is there global warning?
- If so, are Greenhouse Gases the main culprit?

Geochemical Cycle of Carbon Dioxide



Canada's Kyoto Challenge



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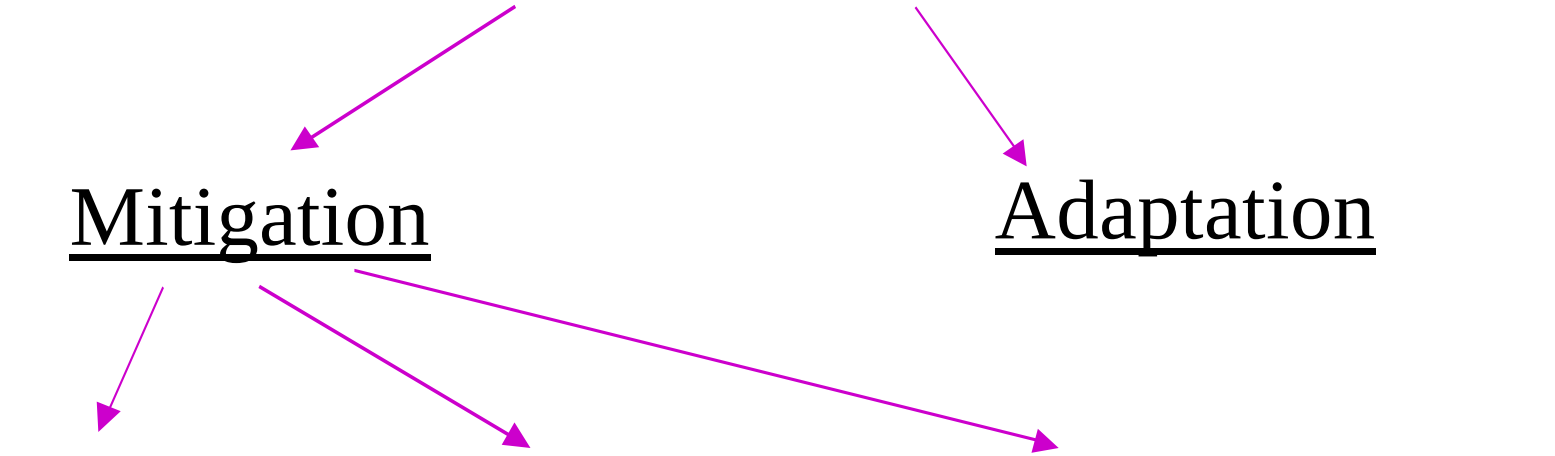
GHG Control Technologies



Adaptation – Areas Affected

- Forests
- Deserts
- Glaciers
- Mountain Regions
- Lakes, Streams and Wetlands
- Coastal Systems and Oceans
- Grasslands

Adaptation - Disciplines

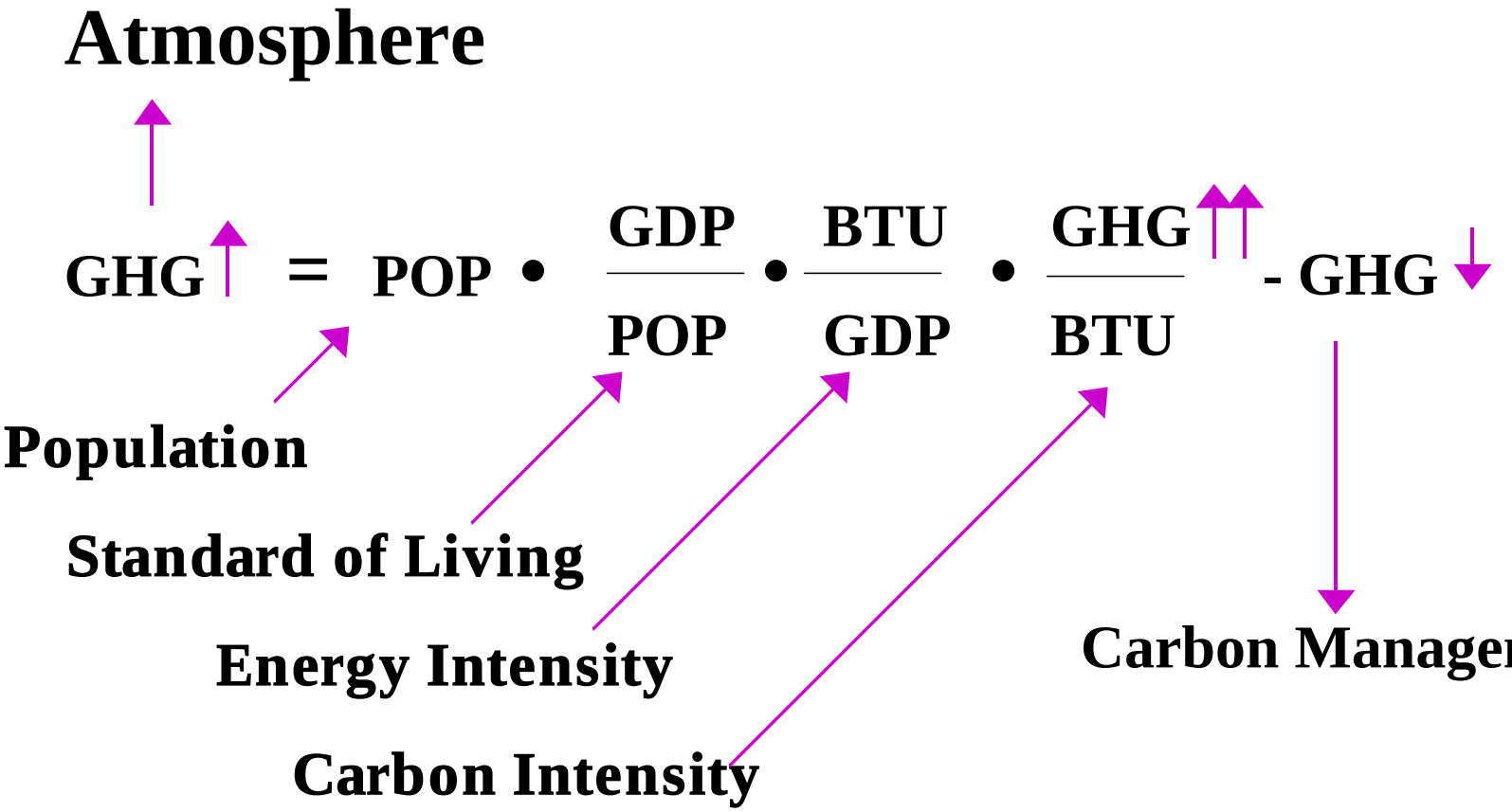
- Water Resource Management
- Food and Fiber (Agriculture)
- Forest Products
- Fisheries
- Weather
- Human Health

Adaptation - Solutions

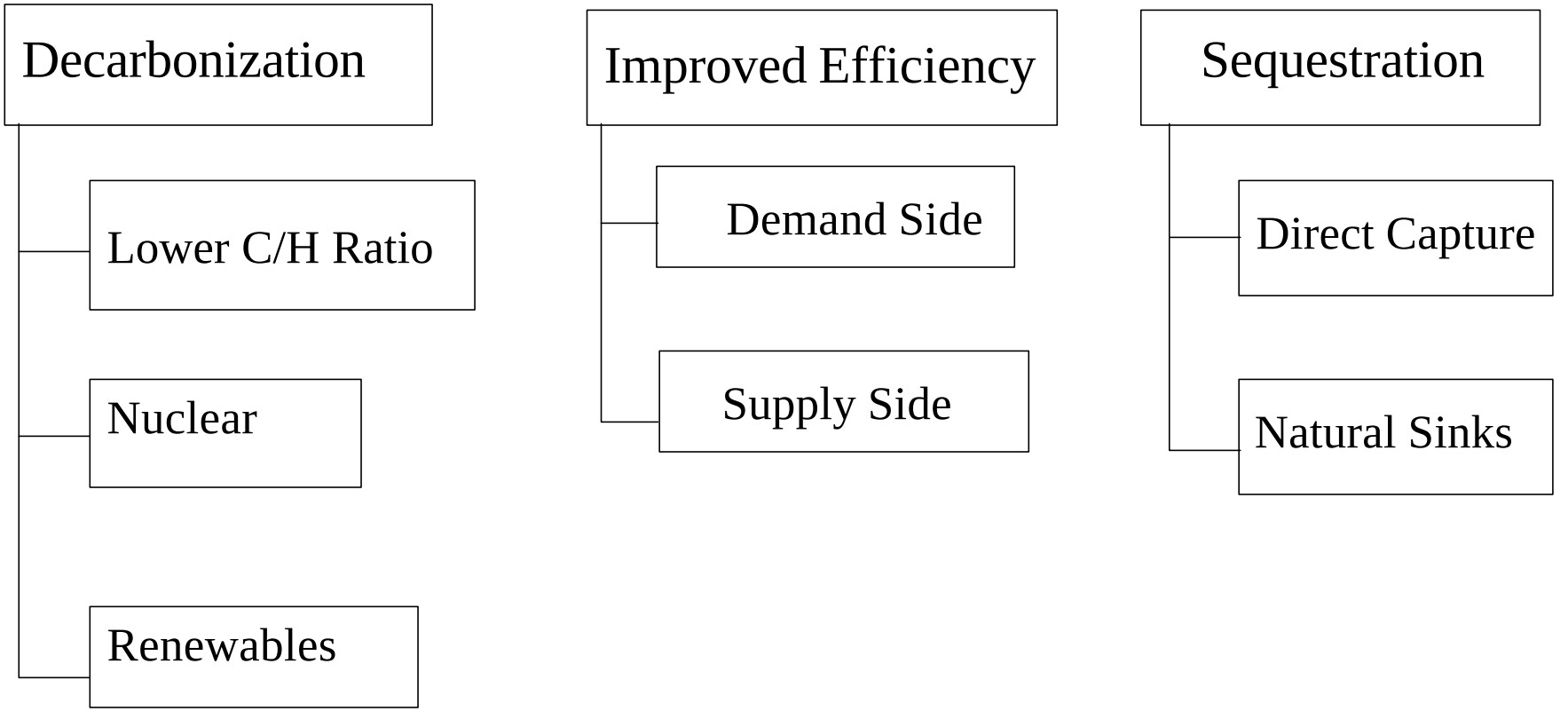
- Relocation of populations
- Remanage land areas
- Prevent flooding by building dikes
- Change agriculture patterns
- Provide special health care for affected areas
- Economic assistance
- Practice conservation

Greenhouse Gas Mitigation Approach

Atmosphere

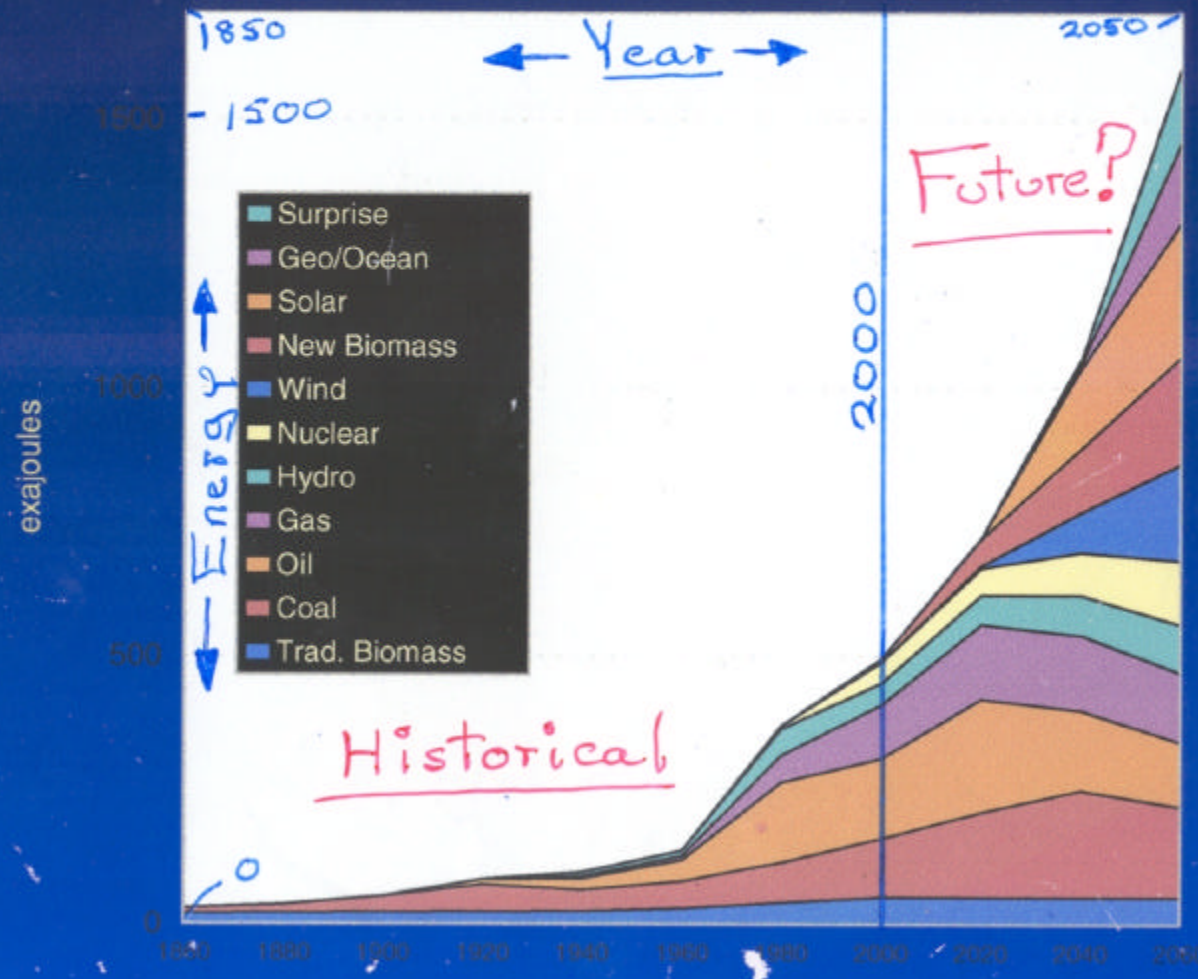


CO_2 Mitigation Options



Sustainable Growth Scenario

(Shell International)



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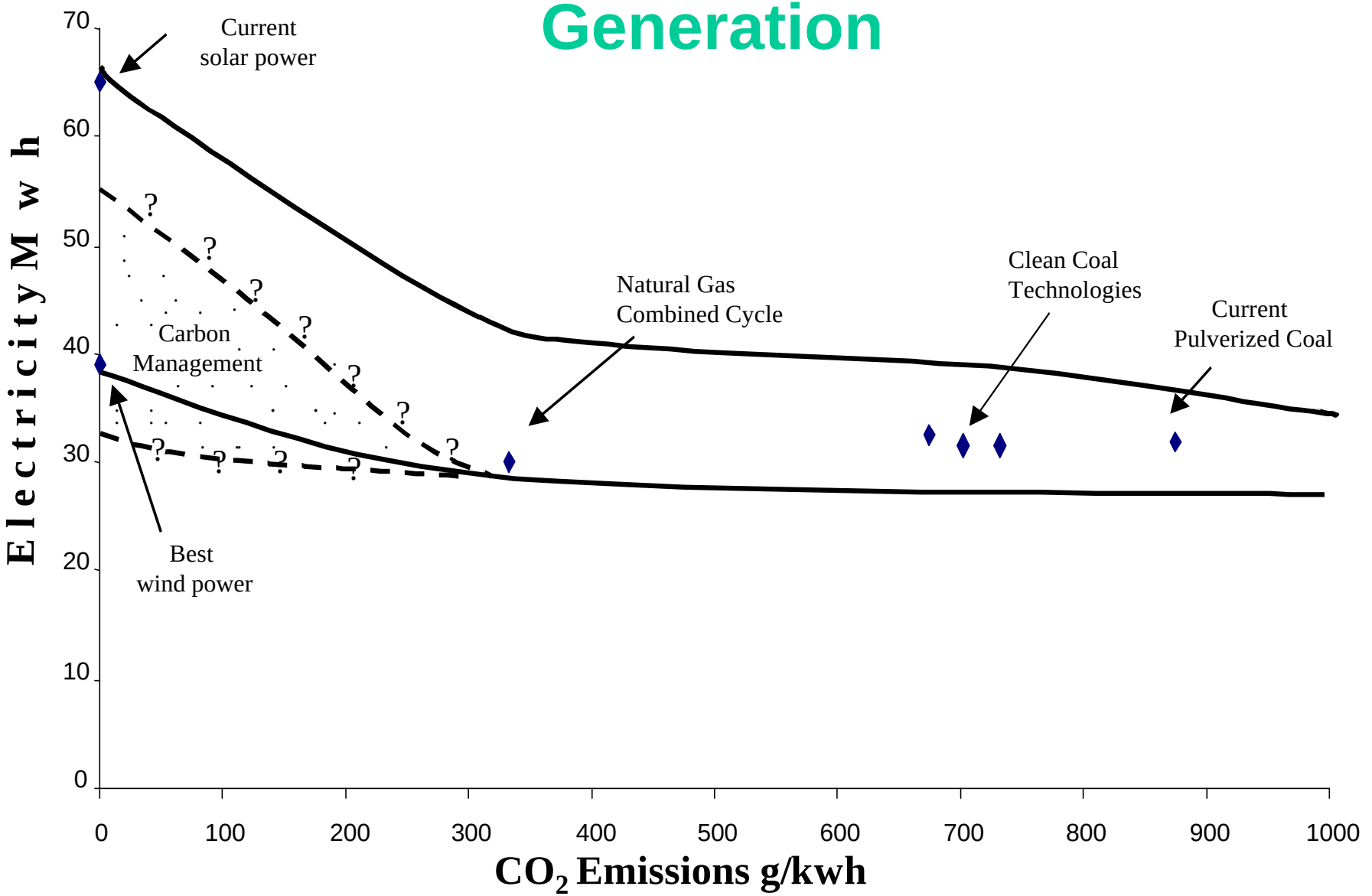
Costs and CO_2 Emissions in Electricity Generation



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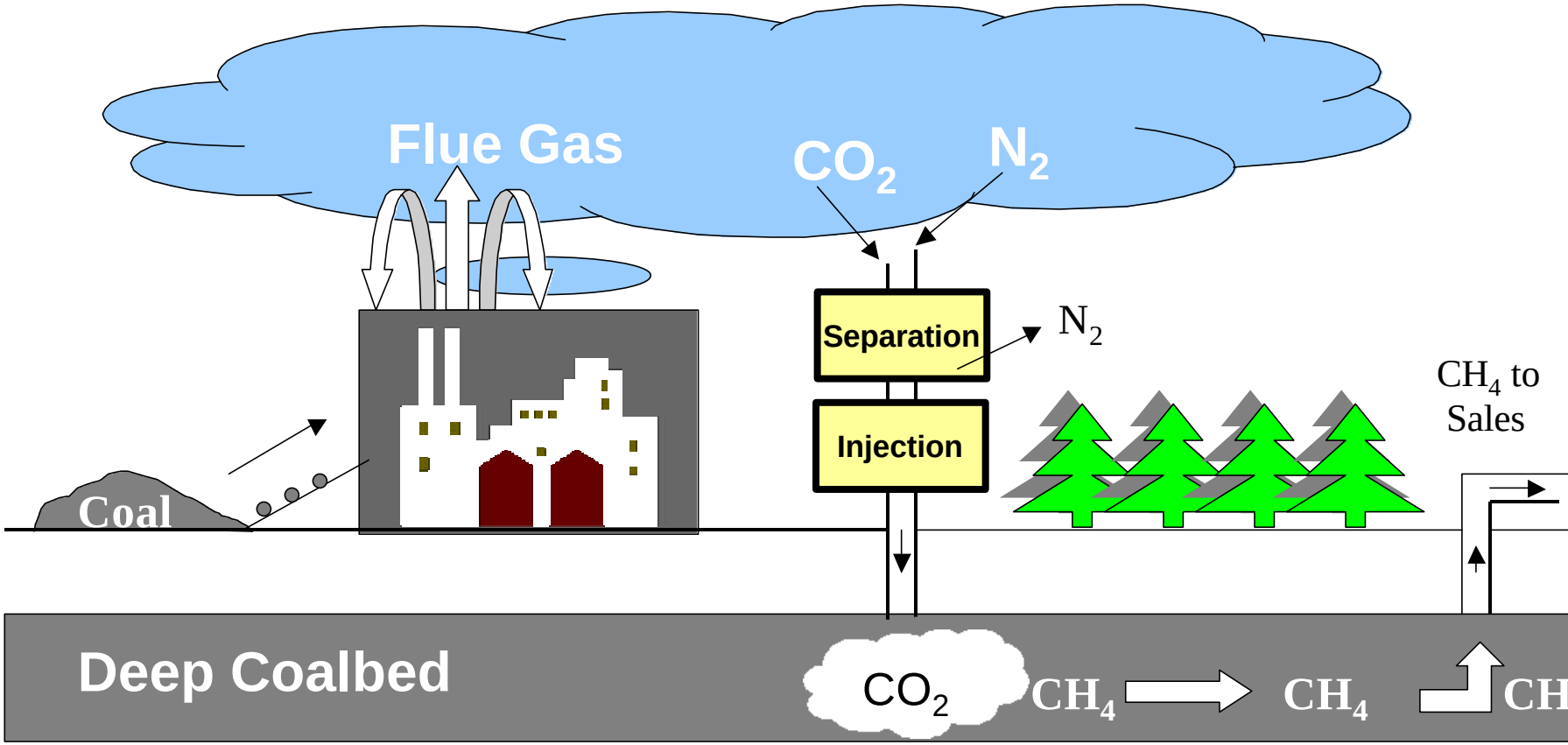
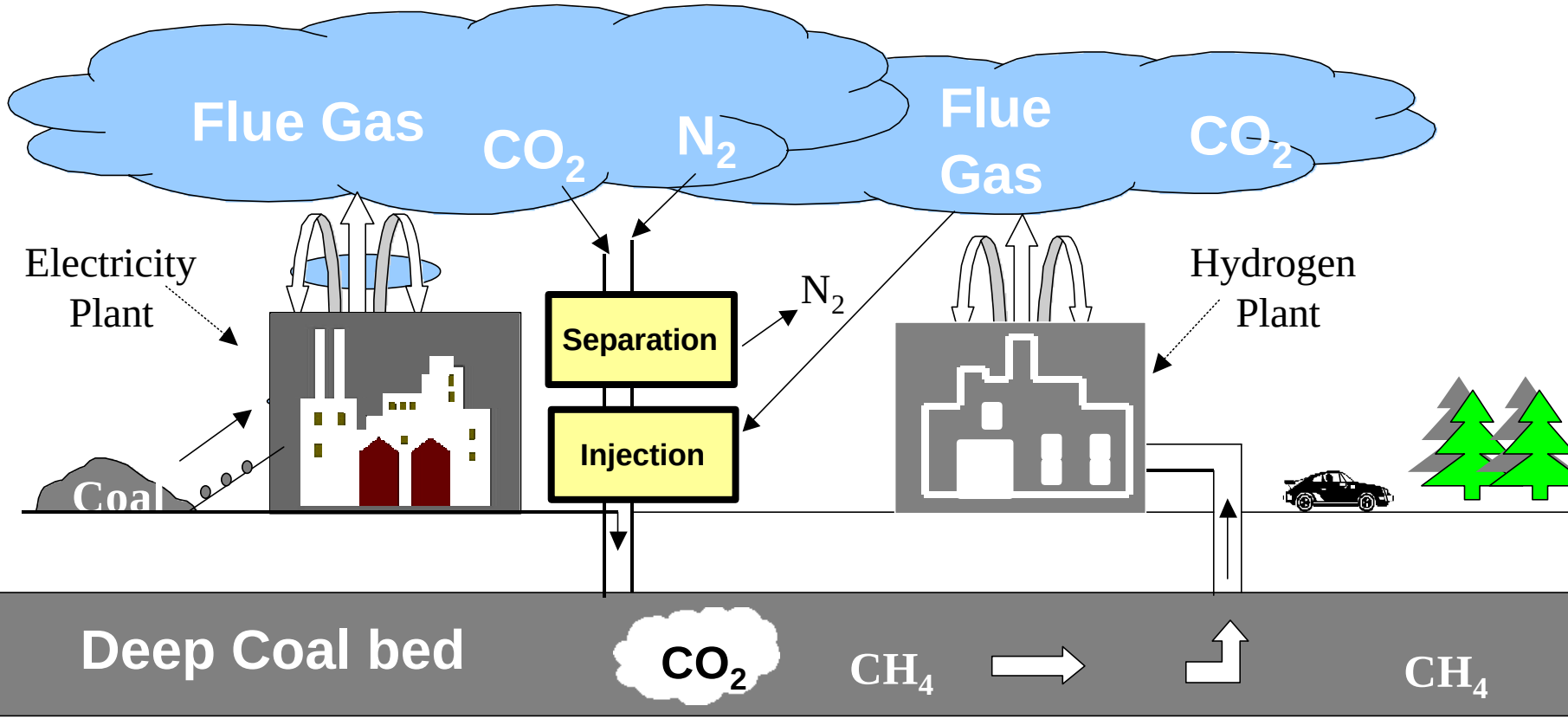
Integrated System for Electricity, H_2 and Heat

- Gains in efficiency (Combined Cycle, Cogeneration)
- Decreases on environmental liability (CO_2, Sox, Nox, Particulates)
- Central Power versus Distributed Power

Zero Emission Power Plants

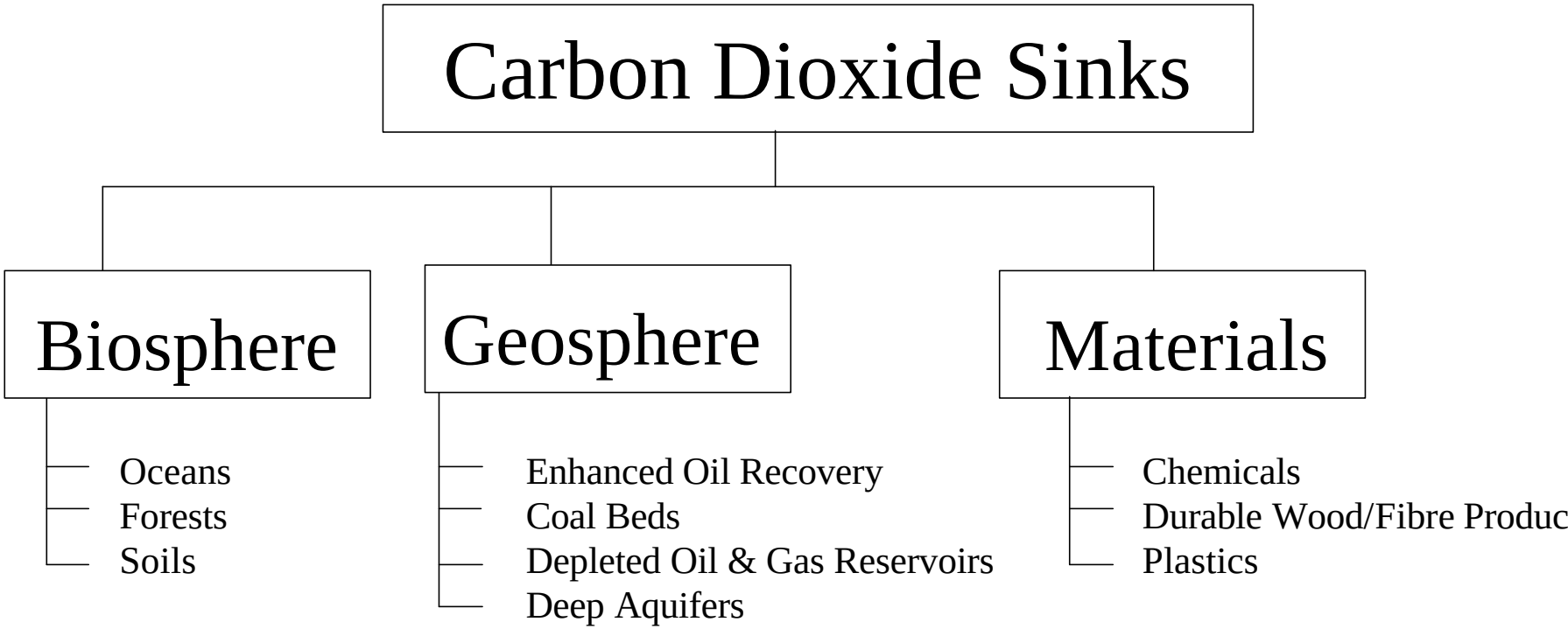


Zero Emission Power Plants

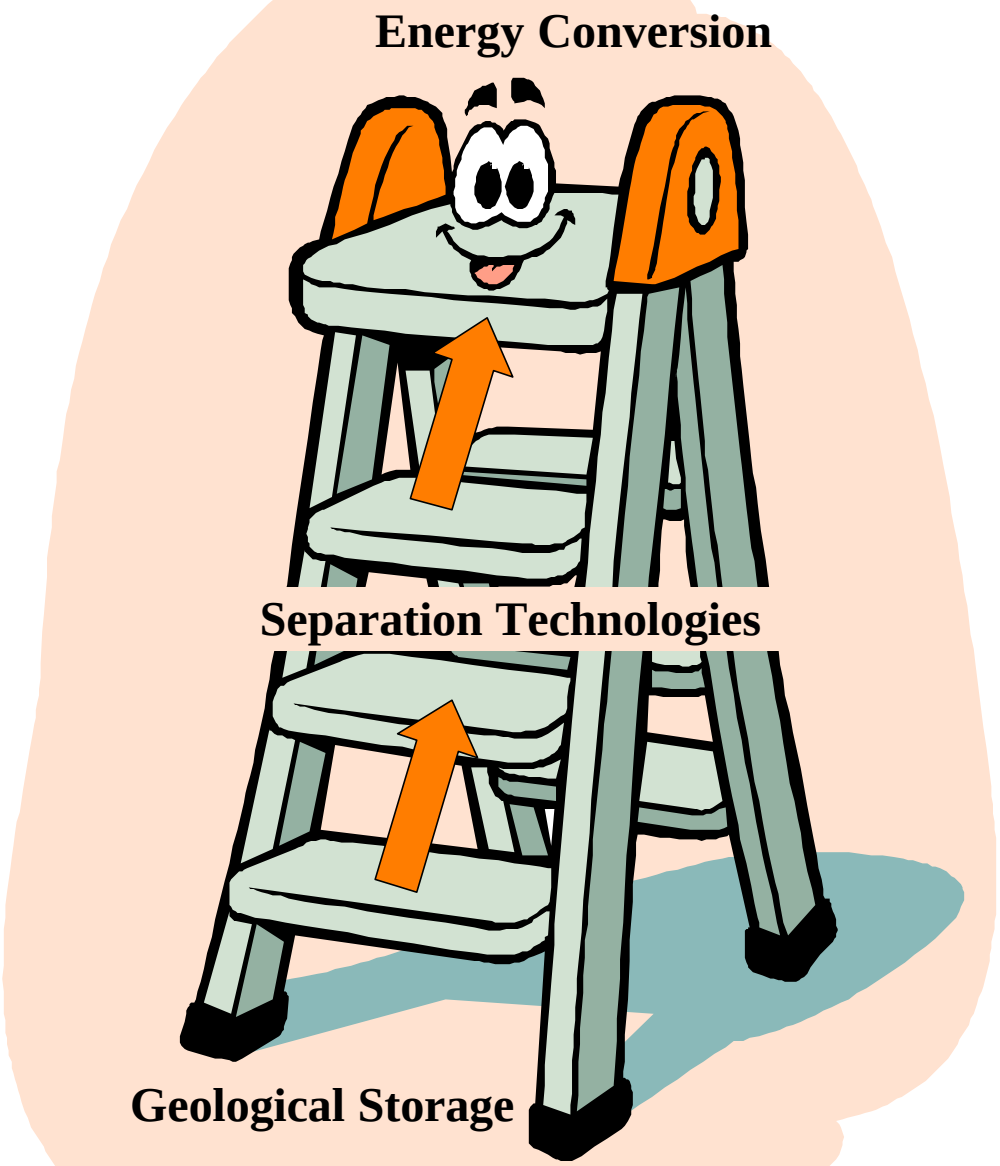


Two CO_2 molecules displace one CH_4 molecule in the coal bed

Figure 1. Classes of Carbon Dioxide Sinks



Decarbonization of Fossil Fuels



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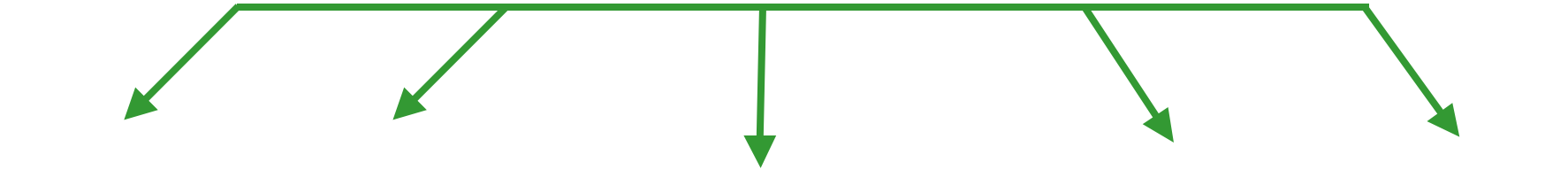
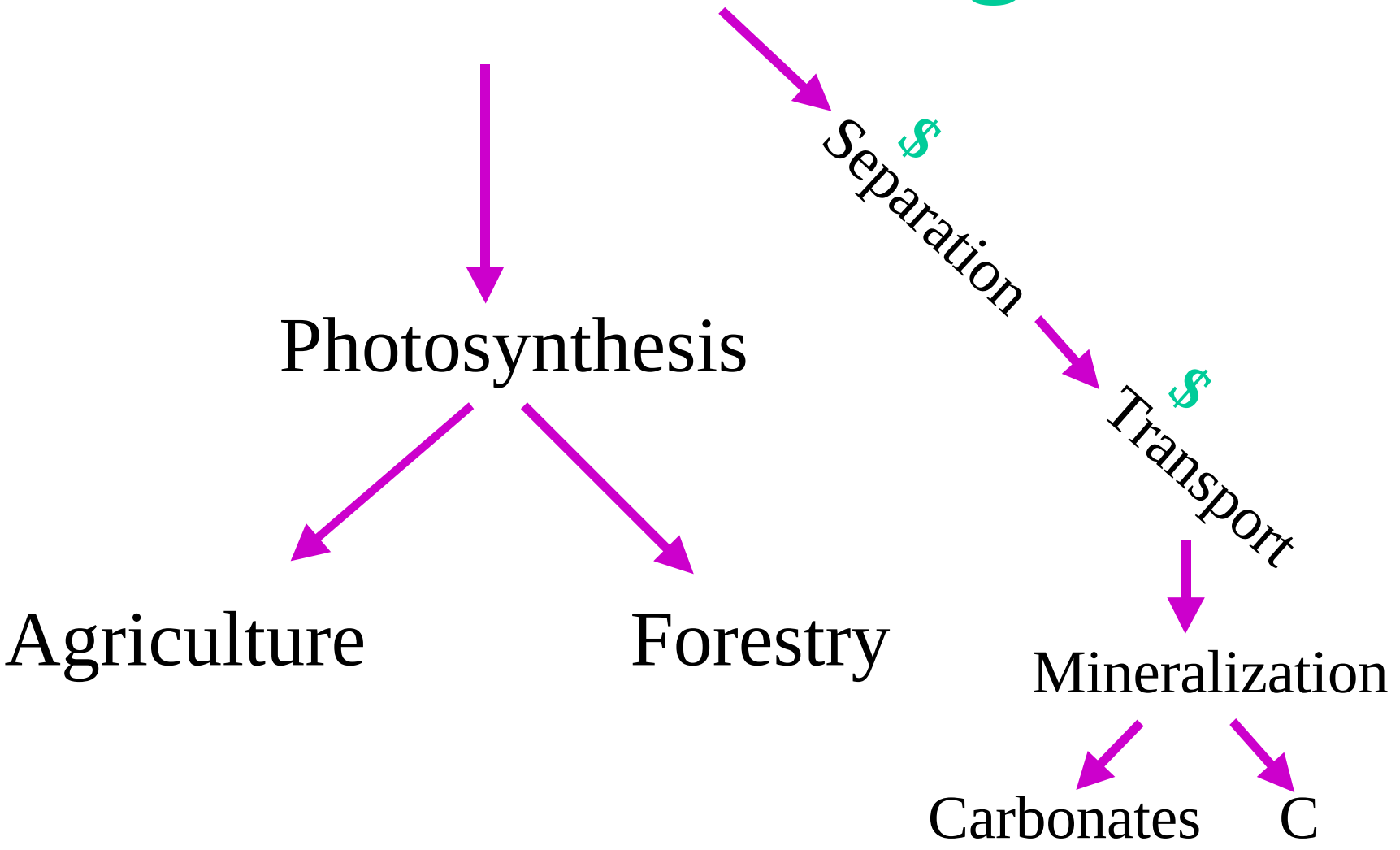
Products

- Of High Value -



- Of Low Value -

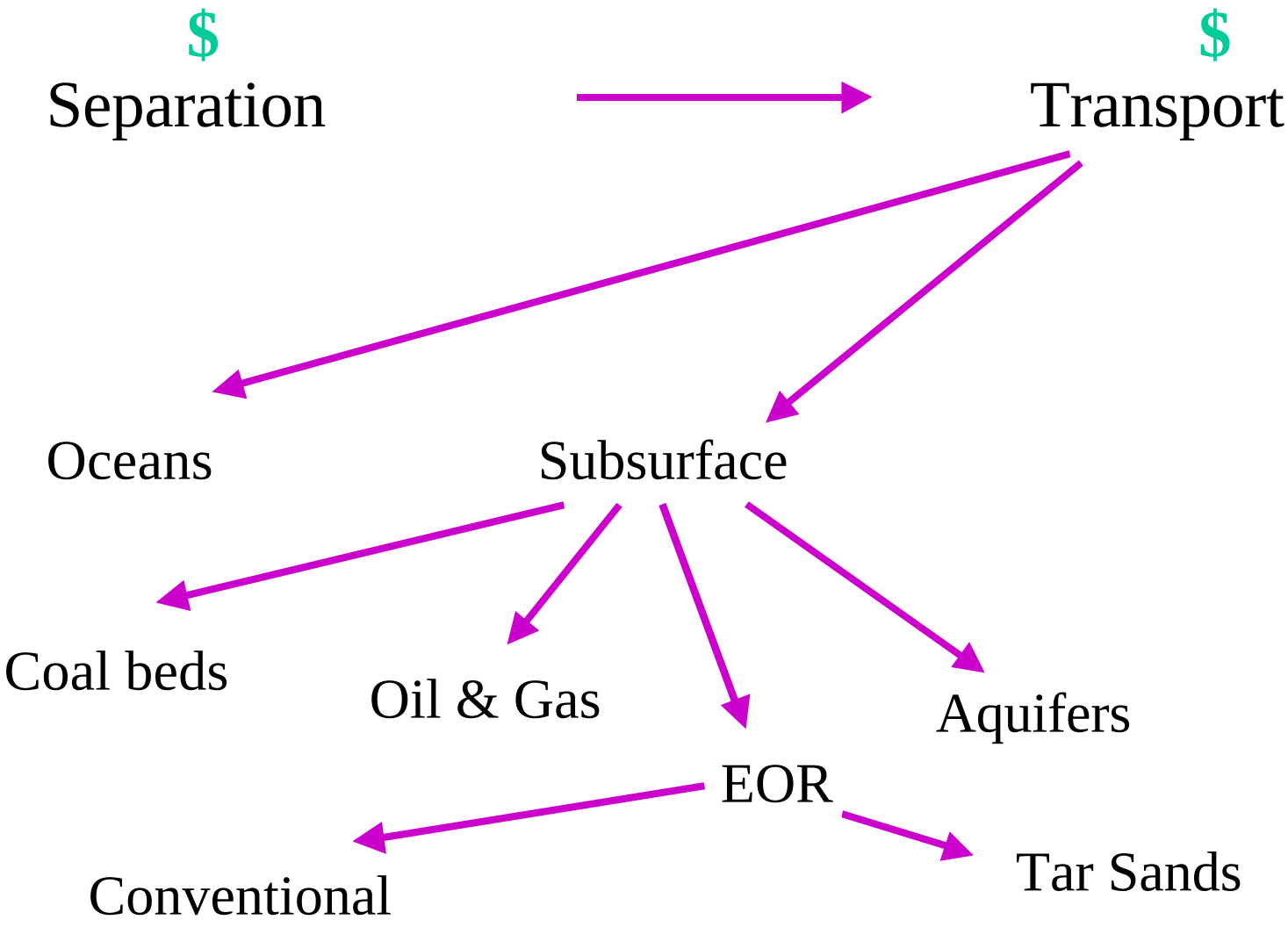
Surface Storage



Biosphere Sinks

Sink	Global ($Gt\ CO_2$)	Capacities -Canada ($Mt\ CO_2$)	Capacities -Alberta ($Mt\ CO_2$)	Retention -Time (Years)	Seq. Rates -Alberta ($Mt\ CO_2/yr$)
Oceans	4400	No Estimate	Not Applicable	<1000	
Forestry	220-319	4,070	367	50	3.7-7.3
Agriculture	165-447	484 – 1,034	172-367	10s	17.2-36.7

Subsurface Storage



Geosphere Sinks

Sink	Global ($Gt\ CO_2$)	Capacities -Canada ($Mt\ CO_2$)	Capacities -Alberta ($Mt\ CO_2$)	Retention -Time (Years)	Storage Rates -Alberta ($Mt\ CO_2/yr$)
EOR	238	330	220	10s	2.2
Coalbeds	300-964	14,680-28,600	18,350	100,000s-1,000,000s	18
Deleted Oil & Gas Reservoirs	630	18,350	12,850	100,000s-1,000,000s	13
Deep Aquifers	183-51,333	No Estimate	19,800	100,000s-1,000,000s	20

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Sedimentary Basins, Fossil Fuels, Greenhouse Gases and Geological Storage: A Serendipitous Association

- Fossil fuels (oil,gas and coal) are found in sedimentary basins
- The fluid fossil fuels are transported to traps through aquifers
- During conversion of the fossil fuels to energy. Greenhouse gases are created
- Extraction of the fossil fuels have created new storage space (in the subsurface) which can be used for geological storage of greenhouse gases

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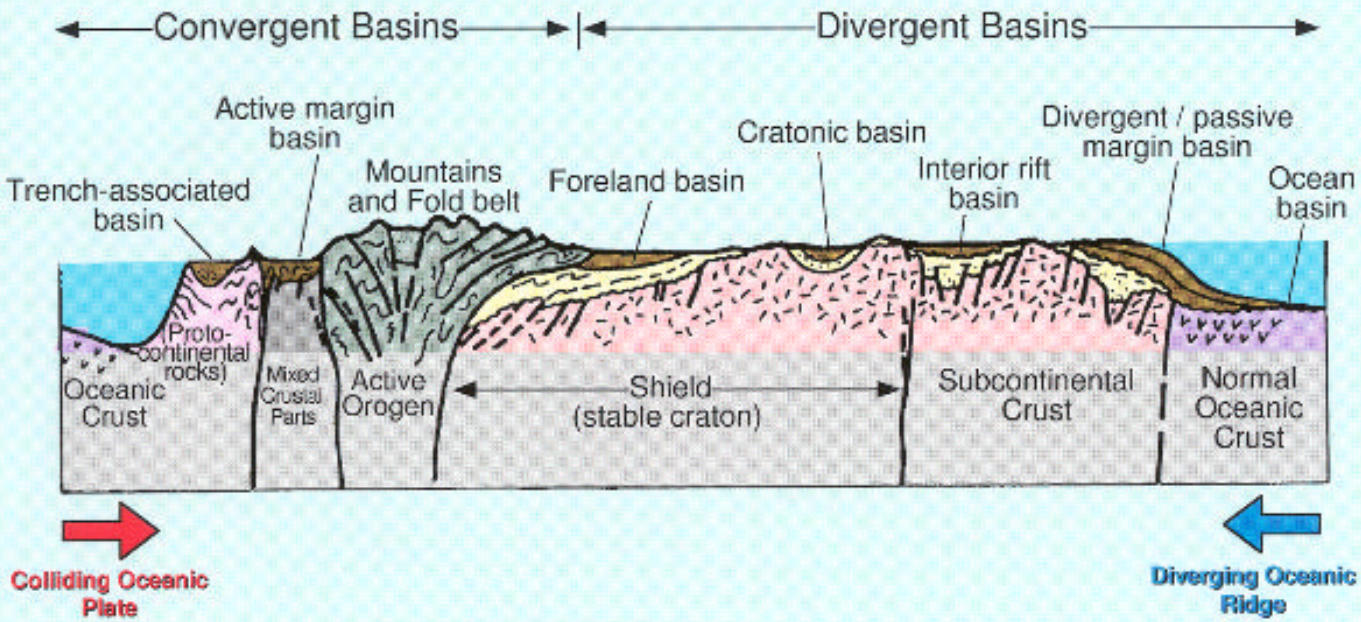
Types of Sedimentary Basins



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sbCO2.7

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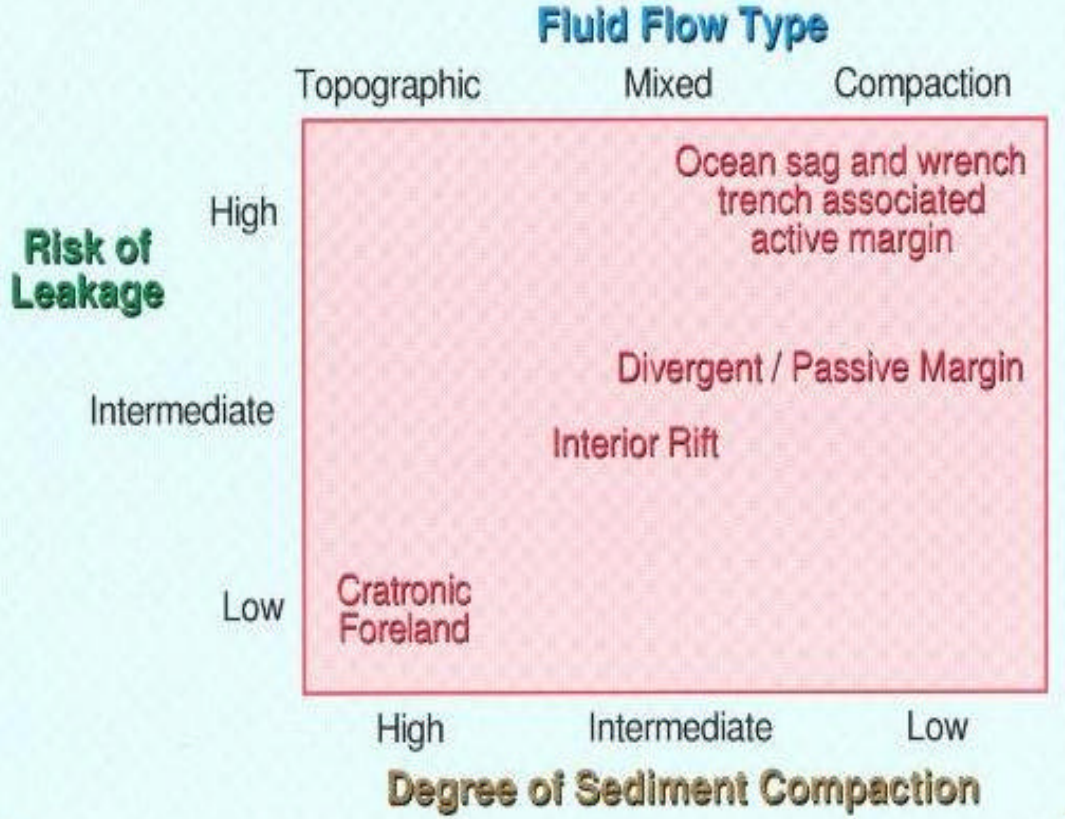
Suitability of Sedimentary Basins to Carbon Dioxide Disposal



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sbCO2.8

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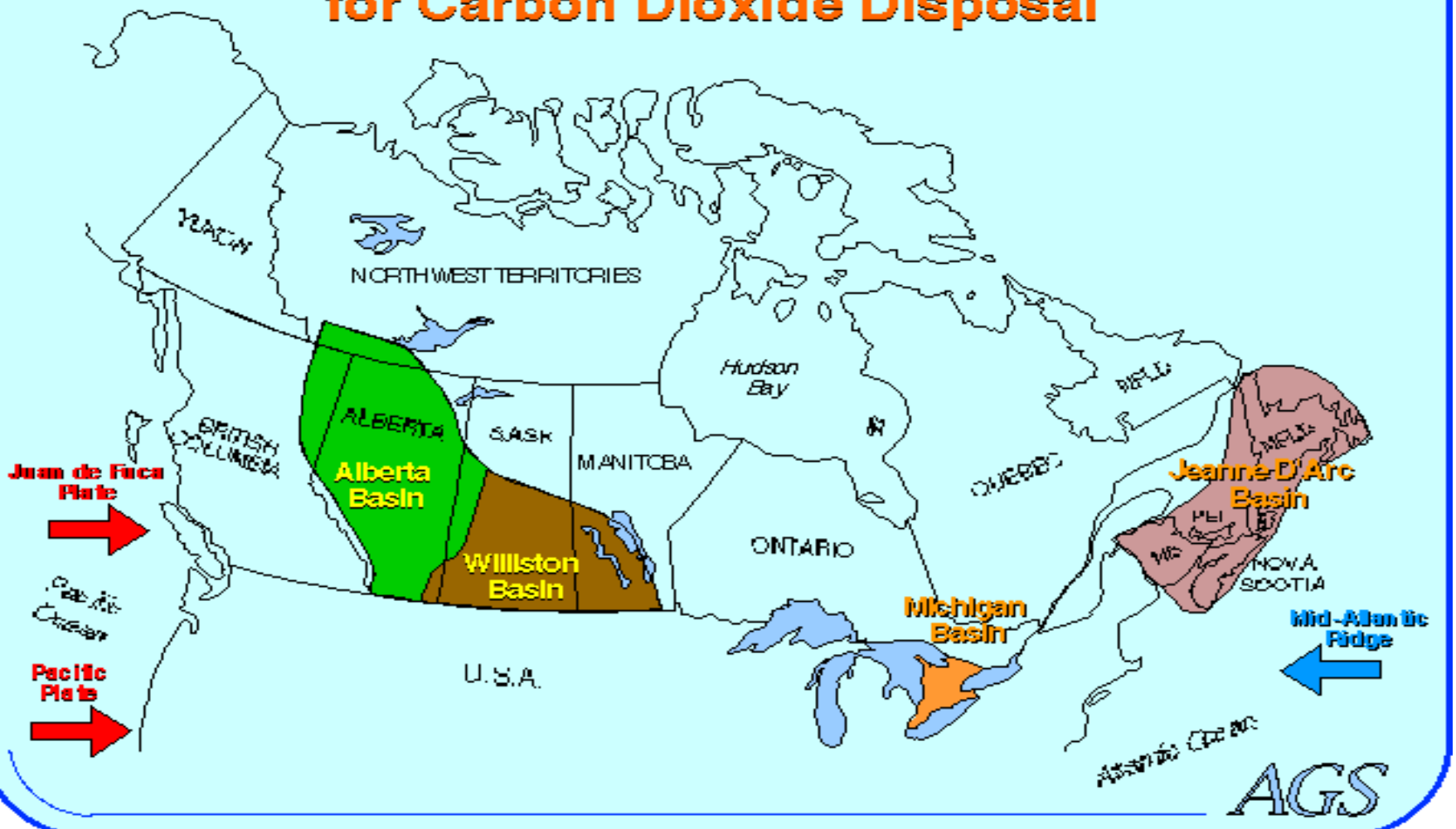
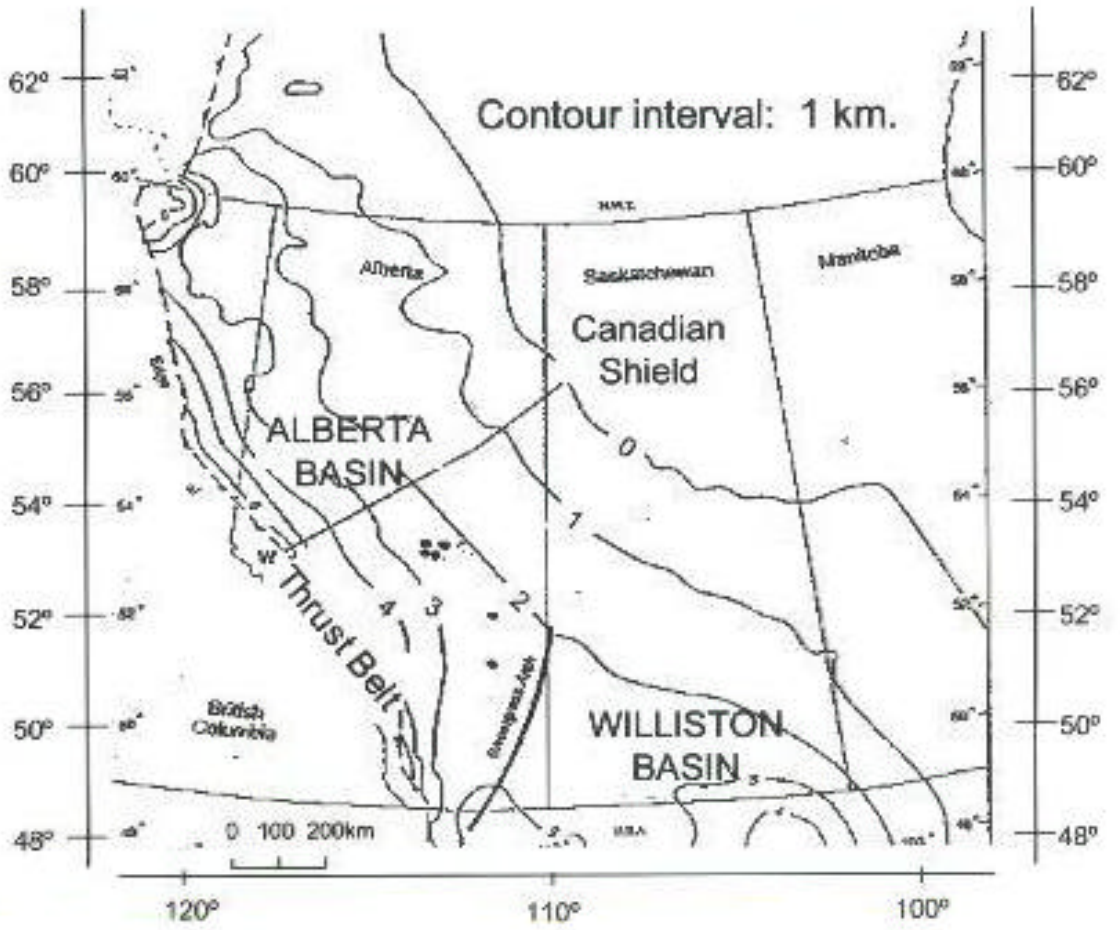
Major Sedimentary Basins in Canada Suitable for Carbon Dioxide Disposal



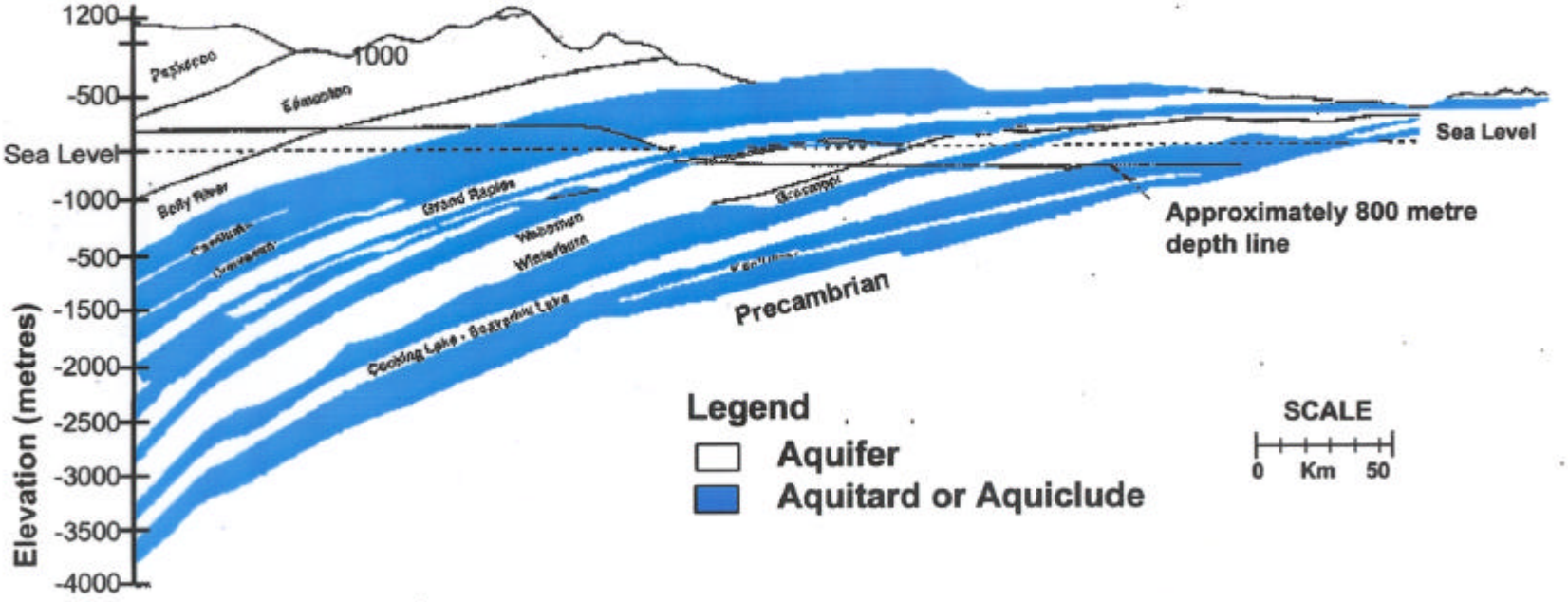
Geological Storage Options for Alberta

- Deep Aquifers
- Depleted Oil and Gas (O&G) Reservoirs
- Depleted Coalbed Methane (CBM) Reservoirs
- Enhanced O&G Recovery
- Enhanced CBM Recovery

Western Canada Sedimentary Basin



Geological Storage



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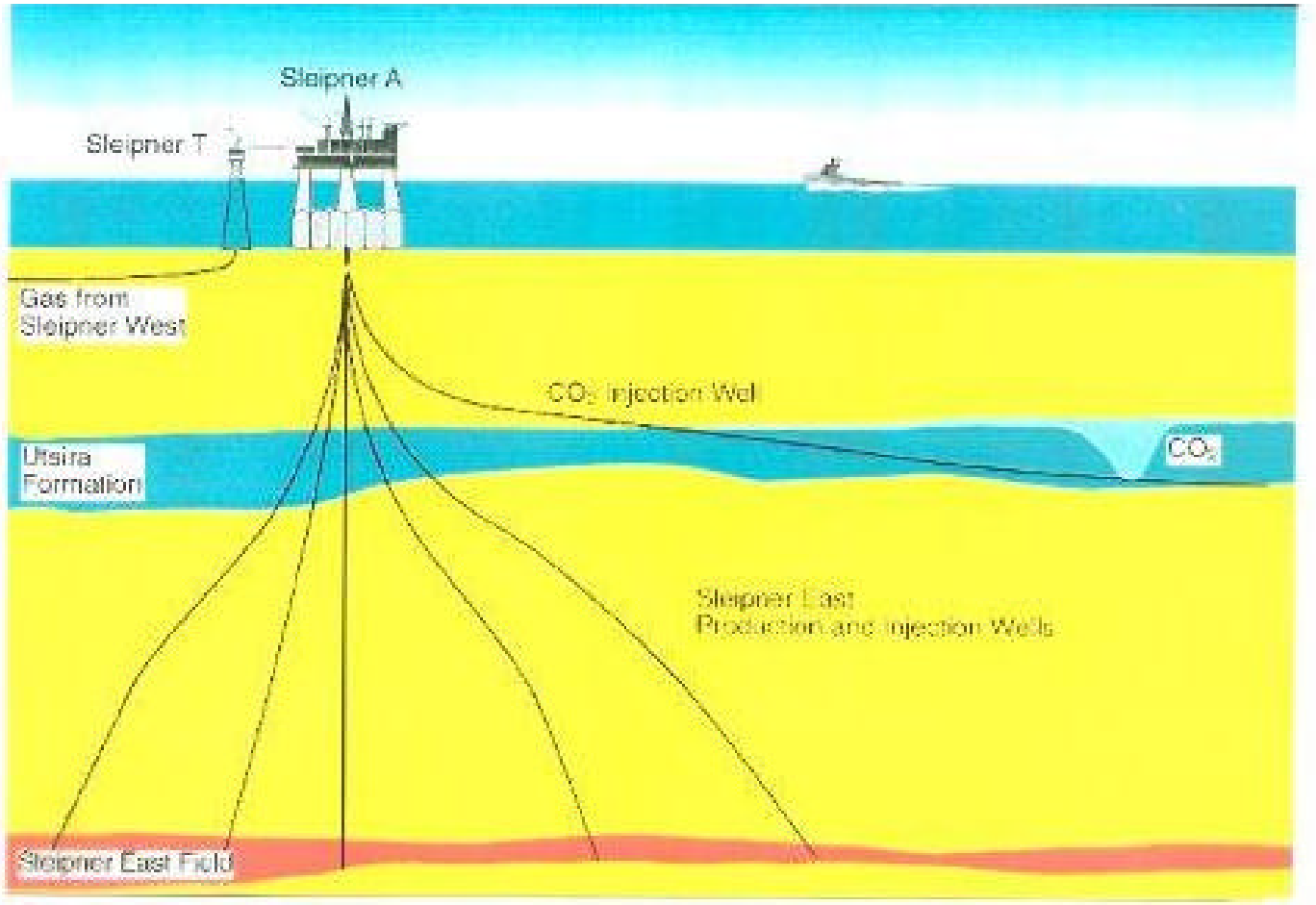
CO_2 Injection into Aquifers



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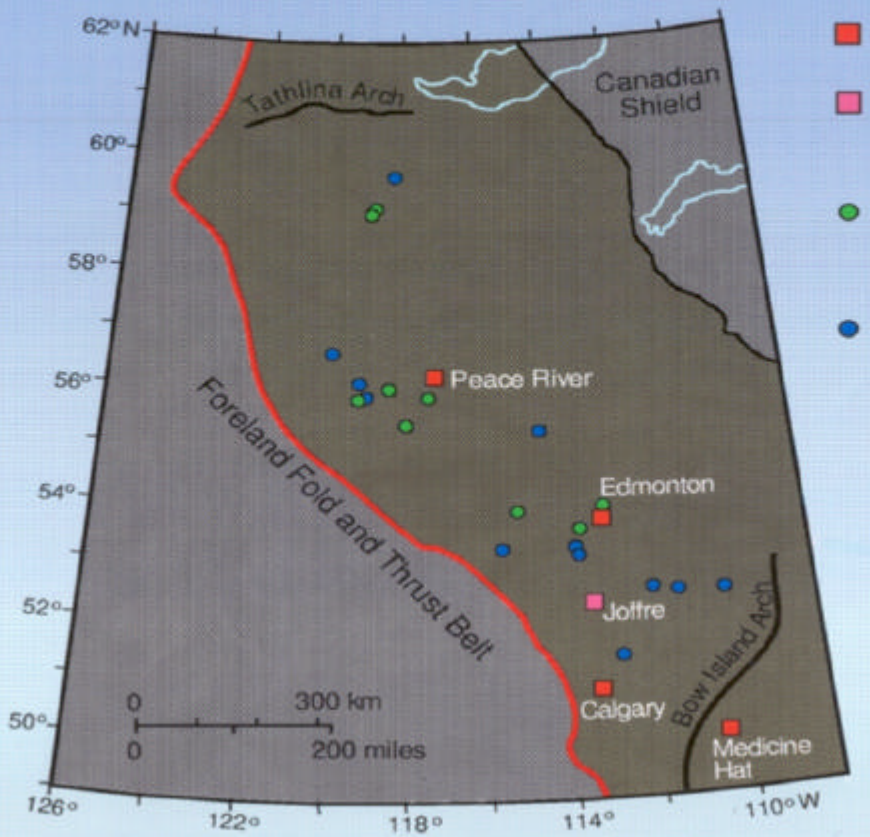
CO_2 Use and Disposal in the Alberta Basin



- Industrial Users
- Enhanced Oil Recovery
- CO_2-H_2S Injection in Depleted Reservoirs
- CO_2-H_2S Injection in Aquifers

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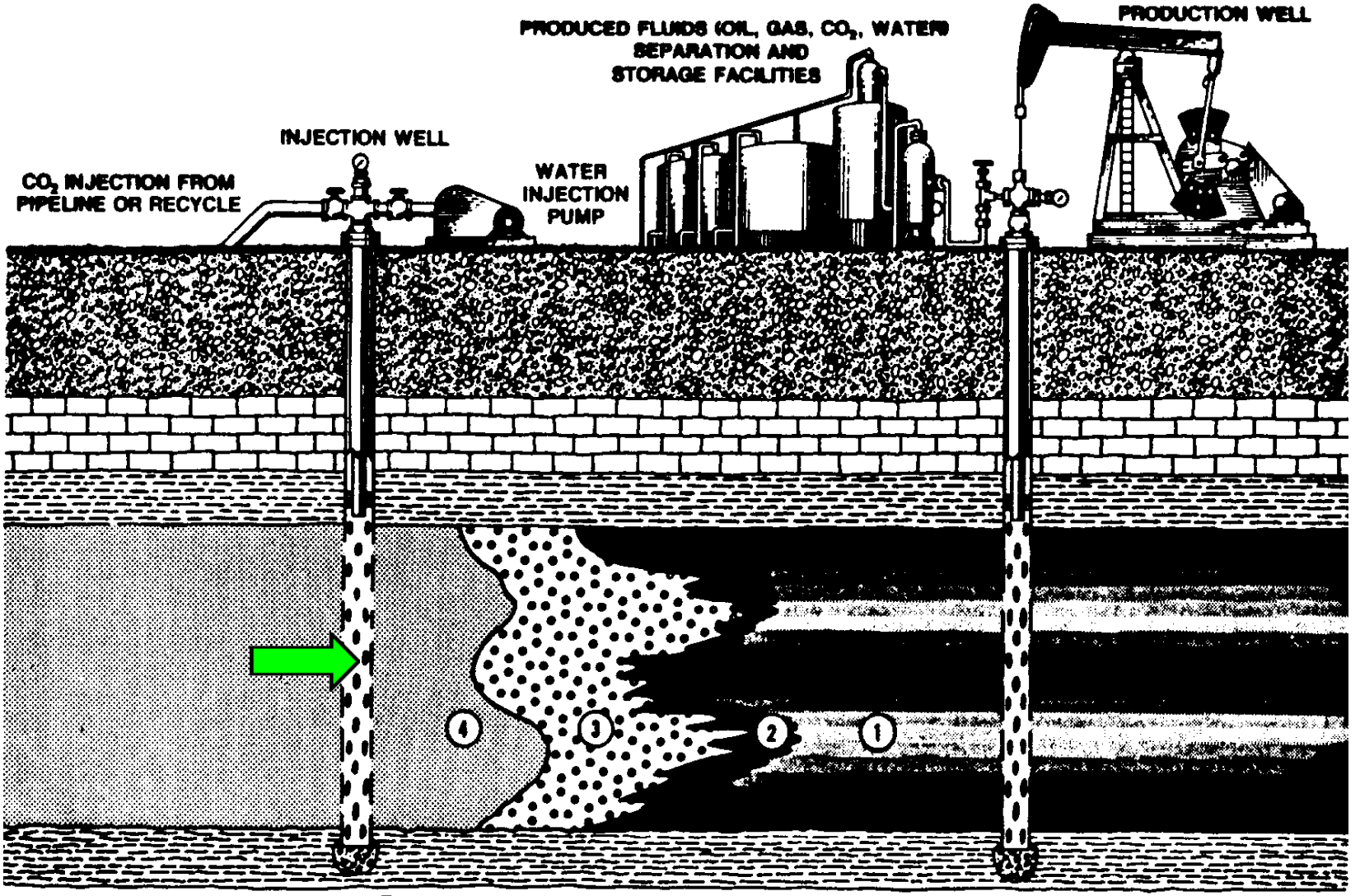
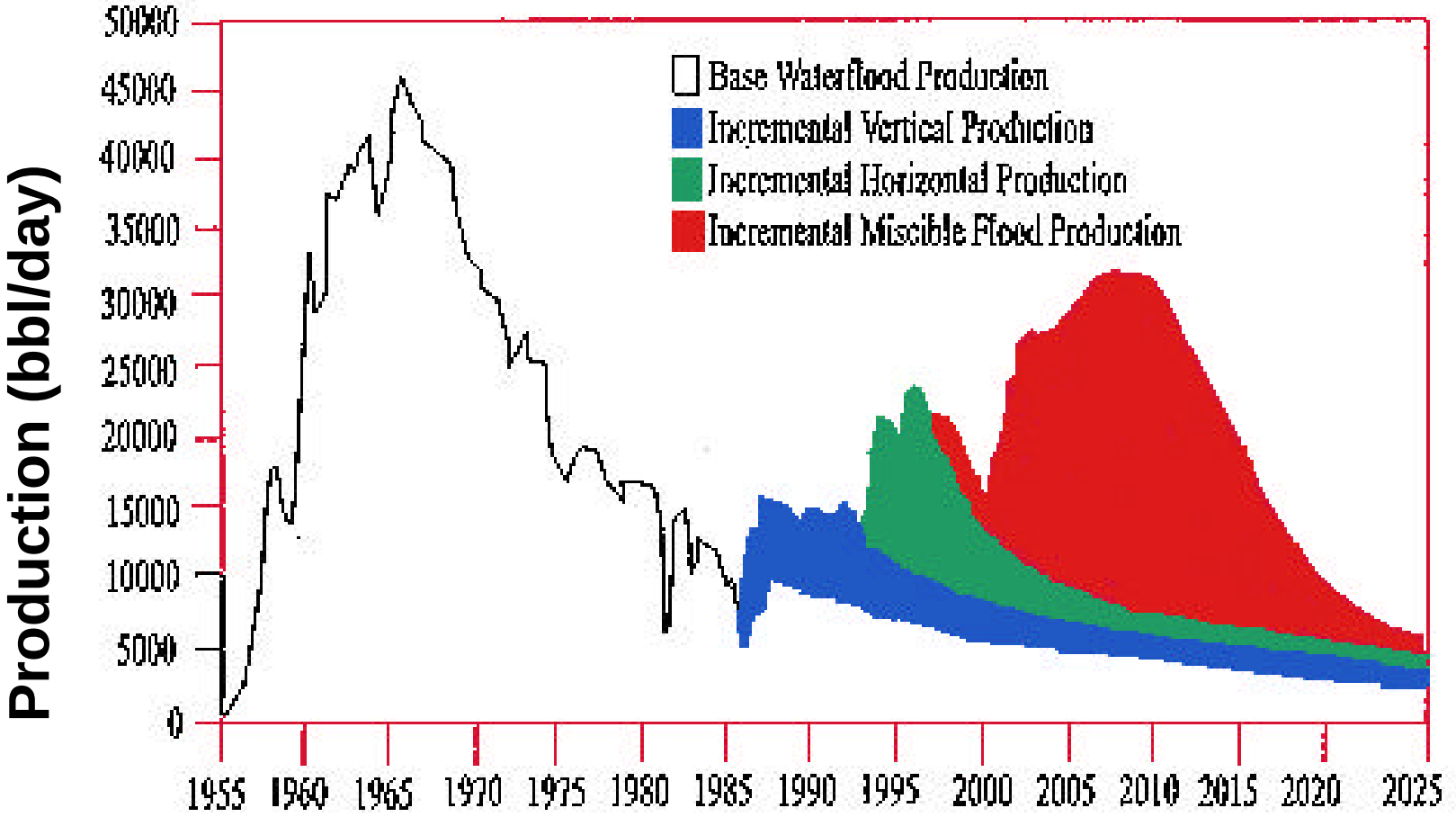
Aquifers

- Injection technology is mature on a small scale
- Ubiquitous
- Need database for hydrology, capacities, locations, stability and ranking
- Treat oil and gas as related to aquifers
- Commercial Projects
  - Sleipner, Norway
  - Acid gas disposal, Alberta

Enhanced Oil Recovery (CO_2 Miscible Flooding)



CO_2 Injection for Enhanced Oil Recovery



PanCanadian, Canada

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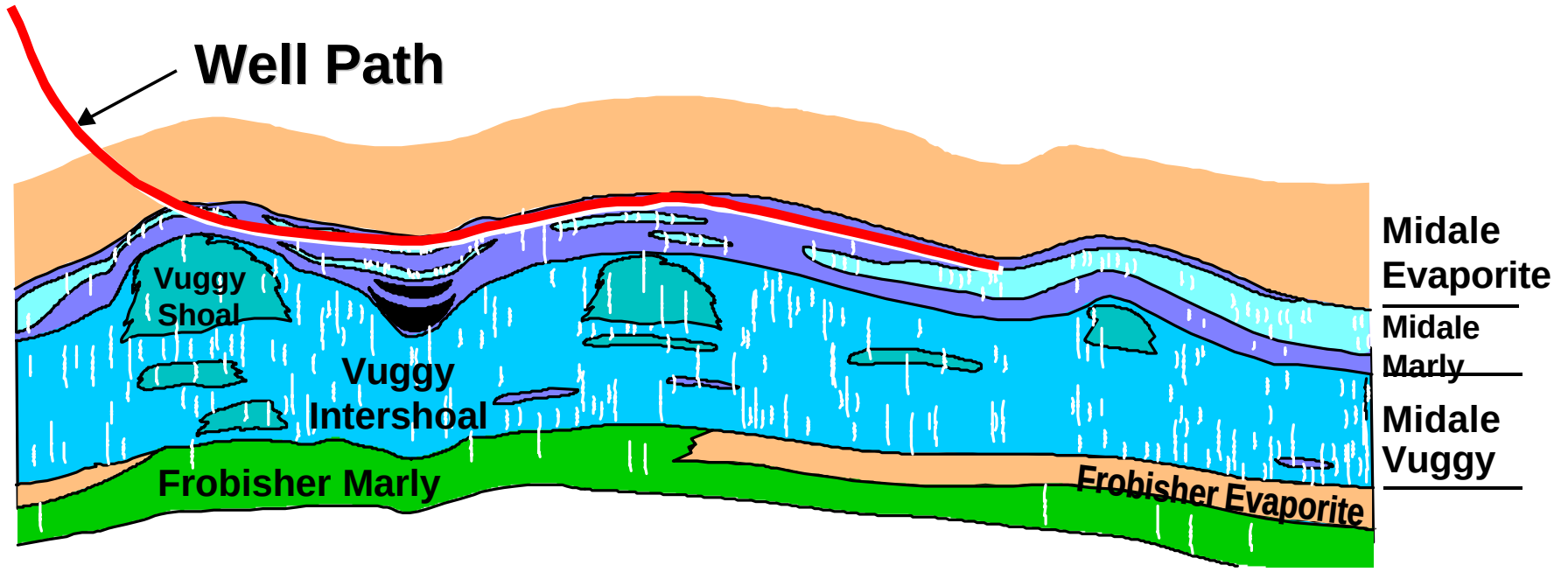
Schematic East-West Geological Cross-Section



- Anhydrite
- Argillaceous Carbonate
- Vuggy Intershoal Limestone
- Marly Dolostone
- Vuggy Shoal Limestone
- Natural Fractures

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Enhanced Oil Recovery → Depleted Oil Reservoirs

- Production technology is mature
- Focus on monitoring and maximizing CO_2 uptake
- Value added
- Proposed commercial projects
  1. Weyburn project, Saskatchewan
  2. BP project, Alaskan North Slope

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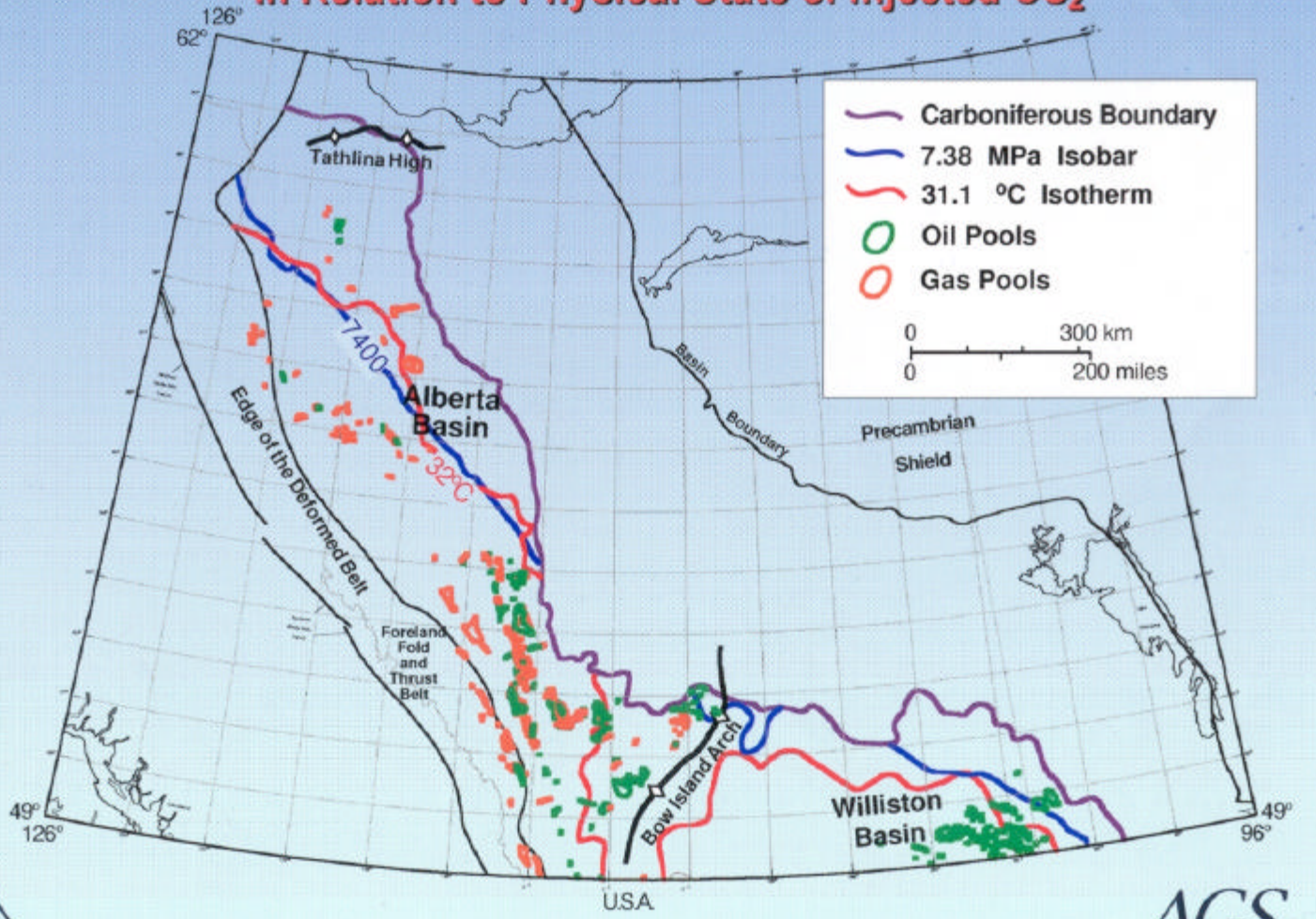
Distribution of MajorOil and Gas Pools in the Carboniferous in Relation to Physical State of Injected CO_2



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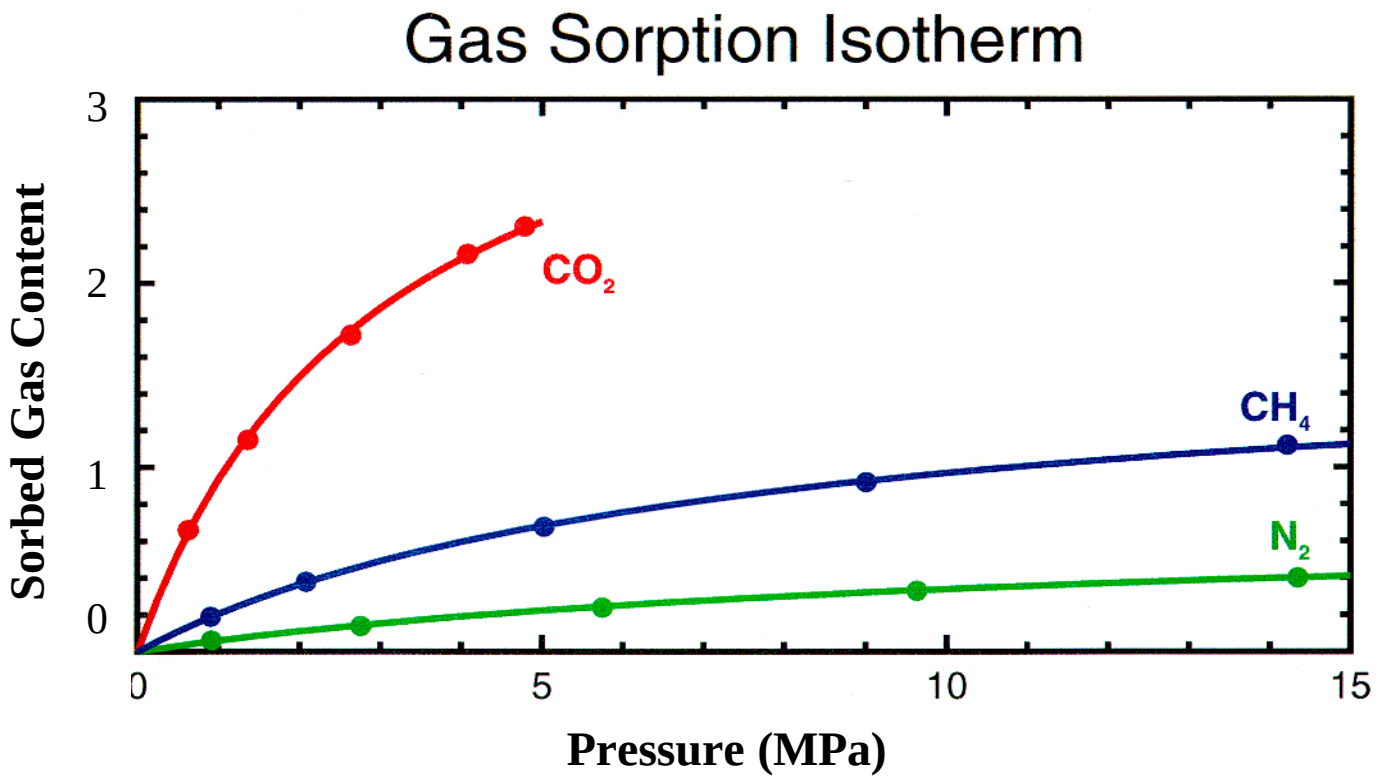
bgMar2000

Depleted Gas Reservoirs

- Storage technology is mature
- Nothing required at this time
- Currently used to store Natural Gas

Sorption Data for Different Pure Gases



Gas Supply Evaluation

Year

2000

- Natural Gas → Heating
- CBM → Heating + Electricity
- ECBM → Enerplex(Electricity +H_2)

Increasing

Sustainability

Increasing

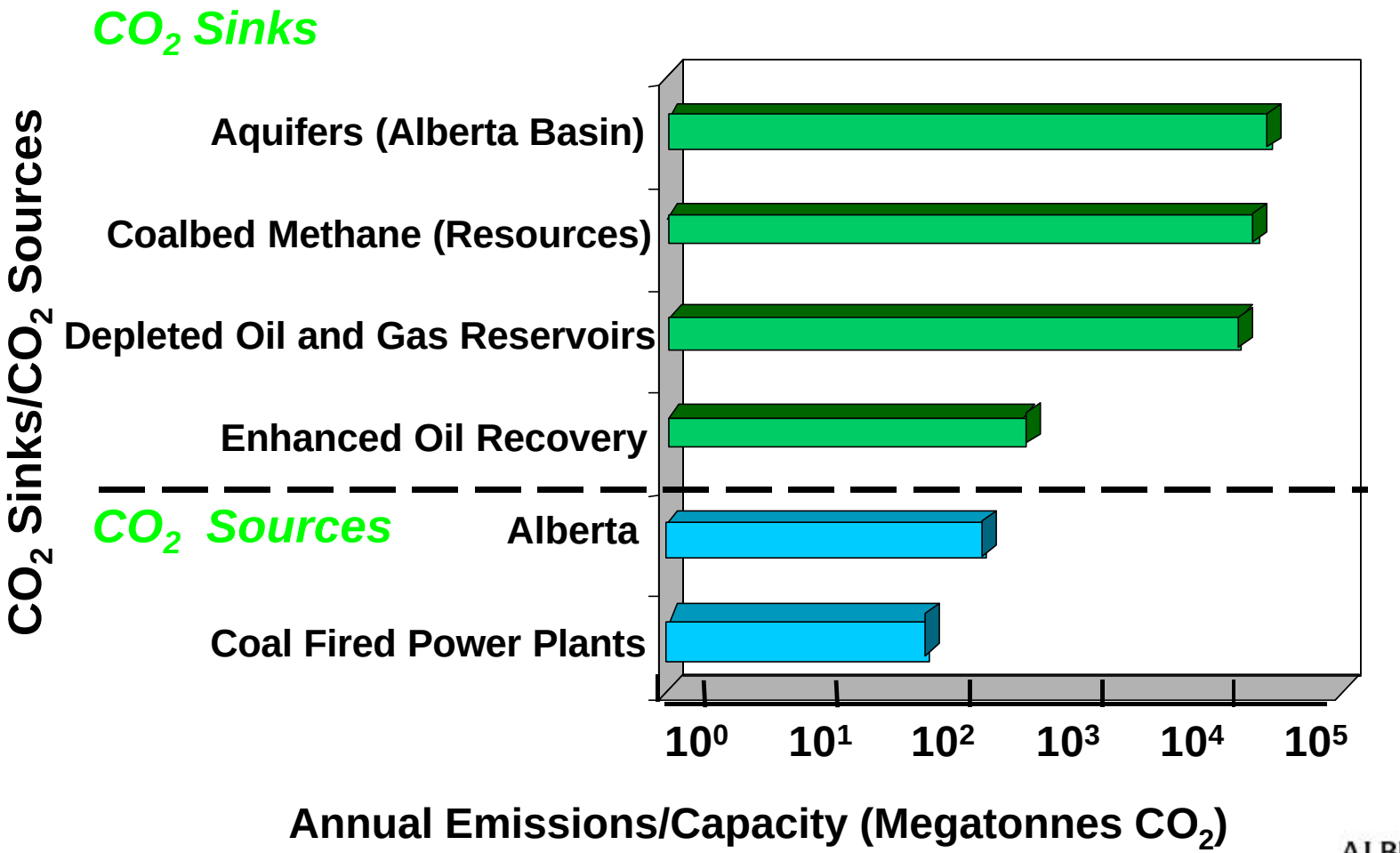
- Methanogensis + ECBM

2100

Enhanced Coalbed Methane

- Technology is immature
- Requires technical demonstration and basic research
- Value added
- Demonstration Projects
  - San Juan Basin , New Mexico
  - Fenn-Big Valley, Alberta

Emissions & Greenhouse Gas Storage Capacity in the Alberta Sedimentary Basin



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Opportunities for Geological Storage of CO_2 in Sedimentary Basins

- Depleted Oil Reservoirs ⟷ Enhanced Recovery (EOR)
- Depleted Coalbed Methane (CBM) Reservoir ⟷ Enhanced CBM
- Depleted Gas Reservoirs ⟷ Enhanced Gas Recovery (EGR)
- Aquifers

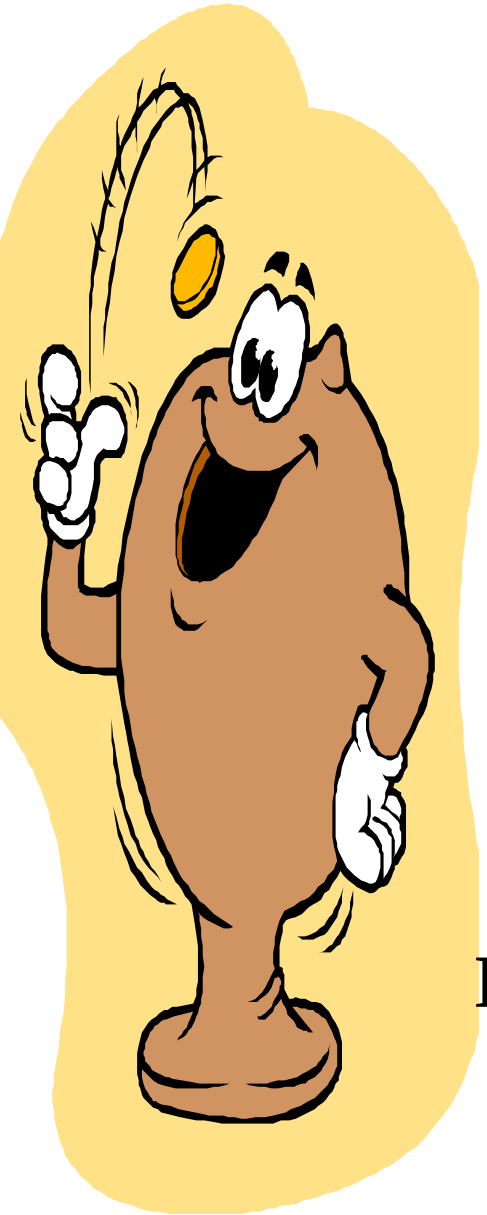
Table 3. Assessment of other issues related to the use of biological and geologic sinks for carbon sequestration

Sink	Environmental Impact	Stability/Security	Verifiability
Biological Sinks			
Ocean	Negative	L	M
Forests	Positive	L-M	L
Agriculture	Positive	L-M	L
Geological Sinks			
Enhanced Oil Recovery	Neutral	M	H
Coal Beds	Neutral	H	H
Depleted Oil & Gas Reservoirs	Neutral	H	H
Deep Aquifers	Neutral	H	H

Note: L=Low: M=Medium: H=High:

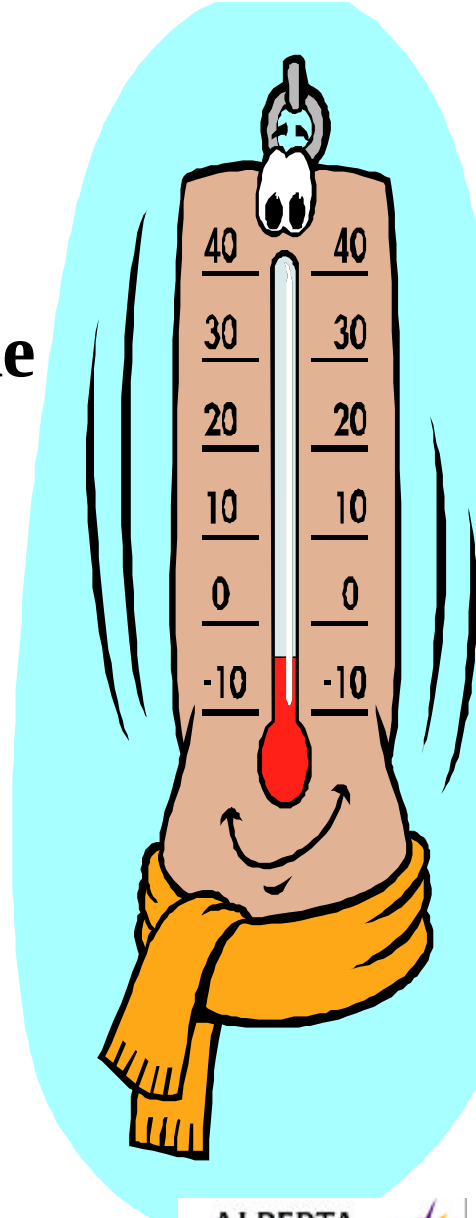
Energy Debate (Economics vs Environment)

- Energy Source (fossil fuels, nuclear, renewables)
- Energy Conversion (H_2, electricity, heat, pressure)
- Energy Use (central vs distributed, conservation)
- Land Use
- Capacity Building



“ I think the reason God made economists is to make sure weather forecastors don’t look so bad”

Gordon Thiessen,
Bank of Canada Governor



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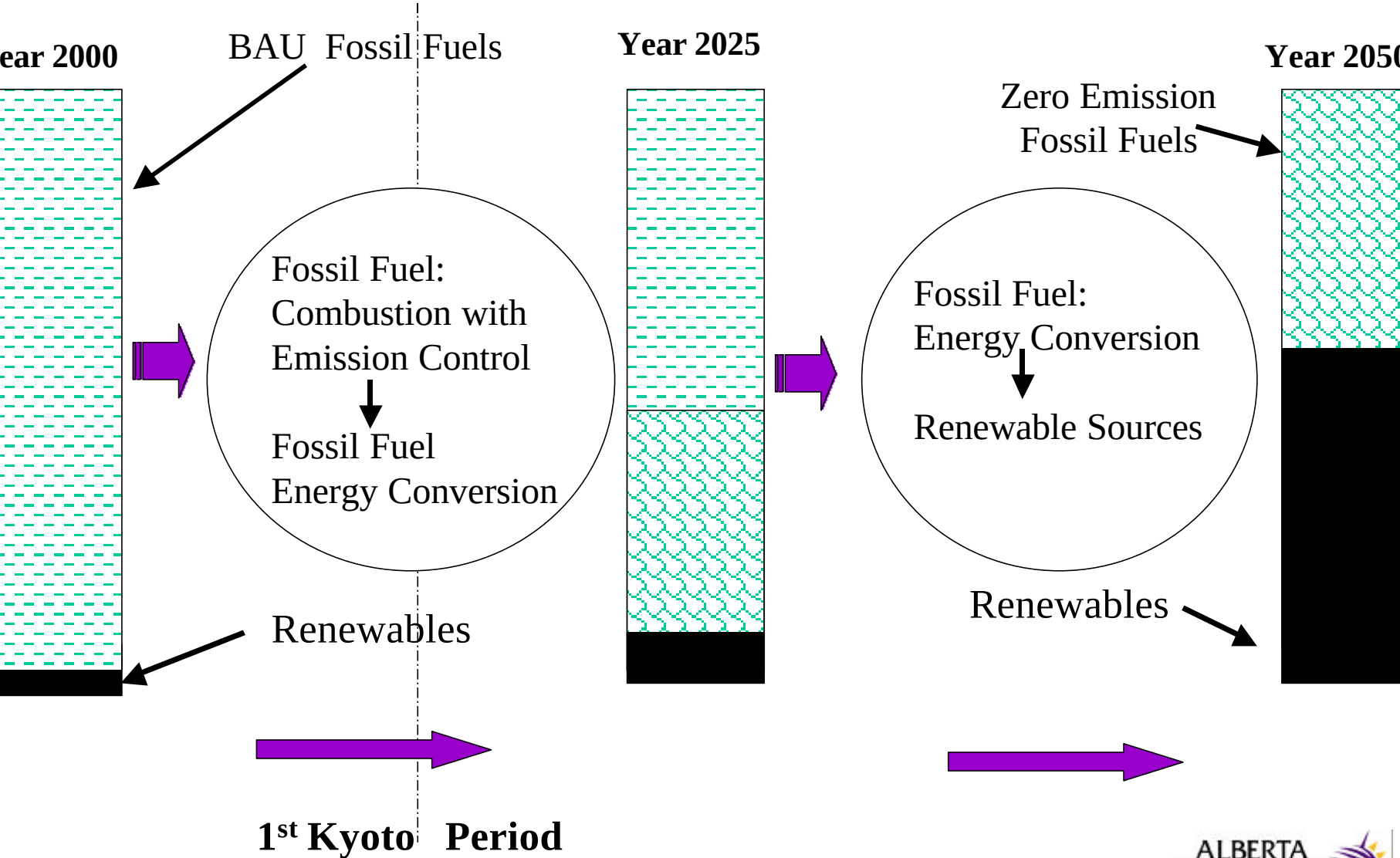
"Making the Energy Transition from Combustion to Zero Emissions"



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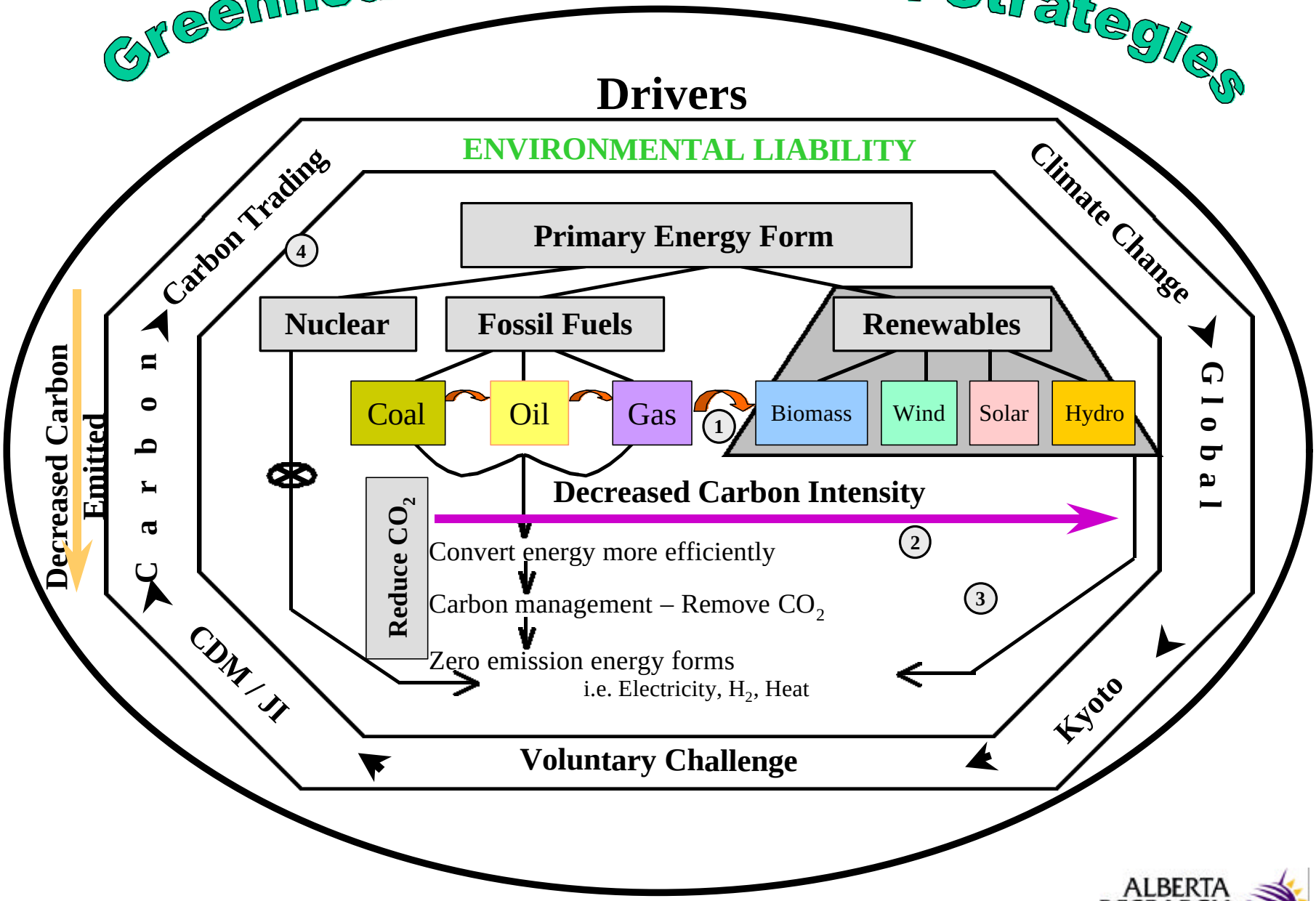
Greenhouse Gas Mitigation Strategies



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“Storage” not “Sequester”

“Sequester” Definition

1. Oxford Dictionary: seclude; isolate; or set apart; separate and reject
2. American Heritage Dictionary: segregate or set apart

   Segregate – to separate or isolate from others or from a main body or group

3. Webster Dictionary: to remove or separate

Sequester = Capture + Compression + Transport + Storage